Hydrology Studies

Groundwater Studies on the Pajarito Plateau

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To assess the impact of Laboratory activities on groundwater quality, Los Alamos has established a Groundwater Protection program to study groundwater flow beneath the entire 43-square-mile area. Five of up to thirty-two wells have already been drilled: R-9, near the eastern Laboratory boundary in Los Alamos Canyon; R-12, near the eastern Laboratory boundary in Sandia Canyon; R-15, in Mortandad Canyon; R-25, on the south rim of Cañon de Valle at TA-16; and R-31, near the eastern Laboratory boundary in Ancho Canyon. Our role is to plan and oversee characterization aspects of the drilling program and to analyze and interpret data from these wells.

We collect various hydrologic, geologic, and geochemical data during drilling and in the completed wells. Our characterization activities include collecting lithologic and geophysical logs, identifying and characterizing perched water zones, collecting of water quality and water-level data, collecting moisture and contaminant profiles through the vadose zone, in situ hyrdraulic tests of individual screens, and studying (mineralogically and geochemically) key hydrogeologic features. In addition, quarterly groundwater sampling of these wells is currently underway to determine spatial and temporal variations in water quality (including contaminants) across the Laboratory. Our data will be used to refine the hydrogeologic conceptual model, provide input and constraints for numerical flow and transport models, and provide input for risk assessment of groundwater pathways.

Our initial results indicate that the hydrogeologic setting beneath the Laboratory is more complex than previously recognized, particularly as it relates to the num-ber, setting, and saturated thickness of perched groundwater bodies. In addition, we can detect Laboratory impacts in groundwater leaving the area along its eastern boundary, but the contaminant concentrations in this ground-water are less than regulatory limits. There is compelling evidence that in some settings surface water reaches the regional aquifer through relatively fast recharge path-ways. Our most significant finding to date is that high-explosive contamination occurs in concentrations above EPA health advisory limits in deep groundwater below a portion of TA-16, located in southwestern part of the Laboratory.

Hydrologic Studies at Technical Area 16

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Los Alamos is pursuing a vigorous program to characterize and clean up legacy waste of the last 50 years. Our project involves characterizing TA-16, a hydro-geologically complex site, which presents a major challenge. TA-16 contains both surface soil sites and alluvial and perched groundwaters that are contaminated with high explosives and barium. To address this contamination problem, we are conducting hydrogeologic studies including stable-isotope investigations and tracer studies, and, in parallel, pilot studies of high-explosive cleanup technologies. Our hydrological model of the area includes multiple recharge sources for subsurface perched groundwater and intermittent saturated zones, which provide fast pathways from contaminated zones to surface water and groundwater. Our initial results suggest significant uncertainties associated with estimated travel times to water supply wells. We are investigating zero-valent iron, composting, natural attenuation, and passive-barriers as possible cleanup technologies. At this point, the zero-valent iron technology appears to be effective for destroying RDX and TNT, but not HMX, in soils. We found that a granular-passive-barrier carbon filter gives good results for removing RDX from water. We plan to continue to investigate cleanup technologies for high explosives in both soil and groundwater. An interim cleanup of the most highly contaminated soils is in progress.

Studying Isotopic Signals of Wastewater Assimilation and Transformation in Wetlands

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Natural and constructed wetlands have tremendous potential to attenuate pollutants and prevent downstream contaminant mobility, and they have proven to be cost-effective systems for treatment of wastewater from industry, agriculture, and sewage treatment facilities at scales ranging from individual households to small communities. We are examining the potential of natural wetlands in a cattail marsh in upper Sandia Canyon to help reduce the mobility of contaminants away from Laboratory property. This marsh will be used as a case study of the ability of wetlands to attenuate pollutants. The cattail marsh receives treated nitrate-elevated sewage effluent from the LANL sewage treatment plant. We are studying the nitrogen, carbon and sulfur isotopic composition of the cattails and wetland waters, as a signal of nutrient attenuation processes. We are also monitoring changes in the wetland geomorphology and hydrology and studying the ability of wetlands in general to reduce other potential laboratory contaminants, such as perchlorate.

Cattails in Sandia Canyon have one of the highest ^{15}N contents documented for plants, with values up to 37.8 per mille. This high percentage of ^{15}N is caused by sewage wastewater, which is enriched in ^{15}N ($\delta^{15}N$ of 32.4 per mille); in situ denitrification of the water results in further enrichment. The $\delta^{13}C$ of cattails reflects variability in the redox conditions in the marsh. First-order variability in these parameters appears to reflect spatial variability in the importance of sewage wastewater versus natural waters, and spatial variation in nitrogen-transforming processes such as denitrification.

Plant isotopic compositions, therefore, can provide a simple, inexpensive proxy to understand attenuation processes in wetlands. The Sandia wetland is a very effective reducing system that can trap or attenuate pollutants, and it could serve as a model for constructed systems that could be used in other LANL canyons to reduce contaminant mobility. Hydrological changes and localized incision occurring in the Sandia wetland will allow us to examine the effect of dewatering on contaminant retention, since wetlands typically must stay flooded in order to remain effective “toxic traps.” We plan to emphasize the potential utility of wetlands as secondary wastewater treatment systems and evaluate means for proper management of such systems.

Hydrogeochemistry of Contaminated Springs at TA-16

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We are examining the hydrogeochemistry of springs adjacent to Technical Area 16 at the Laboratory to determine the extent of high-explosive contamination in the underlying aquifer. Our empirical data coupled with tracer studies will help determine the makeup of the complex, fractured hydrologic system in this area and serve as an excellent test of hydrologic codes used to simulate contaminant transport. This project is discussed in detail in the Research Highlights section.

Aqueous Geochemistry of Uranium and Strontium in Upper Los Alamos Canyon since the Cerro Grande Fire

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Treated aqueous solutions containing uranium, strontium-90, and other solutes have been discharged into upper Los Alamos Canyon from Laboratory activities over the last 50 years. The May 2000 Cerro Grande Fire impacted several major watersheds within the Cerros de los Valles and Pajarito Plateau, including upper Los Alamos Canyon.

The aqueous speciation of surface water has significantly changed since the fire. Increasing solute concentrations of organic carbon, calcium, potassium, bicarbonate, manganese, uranium, and other metals have been observed. Dissolved uranium(VI) complexes with bicarbonate to form soluble complexes, which are poorly adsorbing; this process may explain the eight-fold increase of uranium in the surface water since the Cerro Grande Fire. We also observed strontium-90 (3 to 6 pCi/L), which has been depositing on Ponderosa trees in the area since the 1950s, in the surface water in upper Los Alamos Canyon. The strontium-90 in the water may be explained by the increased calcium(II) species caused by the fire, which compete for adsorption sites on hydrous ferric oxide (HFO) and further decreased uranium and strontium-90 adsorption.

To quantify adsorption of uranyl and strontium onto HFO, we generated a conceptual geochemical model using MINTEQA2 and PHREEQC. We selected the diffuse layer model (DLM) to quantify adsorption of the uranyl cation onto HFO, which occurs as surface coatings on creek sediments and alluvial material. The DLM considers solution speciation and aqueous ion activities and sorbent (solid material) properties (surface area and concentration), sorbate (solute) concentration, and groundwater composition (pH and solute concentration). Results of model simulations closely match observed uranium and strontium distributions in upper Los Alamos Canyon, suggesting that quantifying interfacial processes is possible using field and laboratory investigations and computer simulations.

Hydrogeologic Atlas for the LANL Area

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A 3-D site-wide geologic model of the LANL area was first constructed in 1996 and has been updated yearly as new data are generated. Although this model is compatible with modeling needs, hard copies were difficult to use. To solve this problem, we produced a preliminary atlas in 1999. It consisted of 25 user-friendly conventional subsurface geologic and hydrologic maps of LANL, based on the 1999 geologic model and available hydrologic data. Constructed to fit on most desktops, each type of map was contoured in a unique but standard color, and data used for each map are shown in the same color. A brief documentation accompanying the atlas discusses the design decisions, as well as the source and quality of data. The preliminary atlas included subsurface maps, which indicate the structure, depth, and thickness of major stratigraphic units underlying the Laboratory, a topographic map, a piezometric-surface map, and a map showing the geology at the piezometric surface.

In 2000, we expanded the hydrogeologic atlas from 25 to 45 sheets. The additional sheets include a geologic map, subsurface maps for six geologic units not covered in the preliminary versions, and a selection of cross sections. The expanded atlas also presents several other new kinds of data: the outcrop and subsurface extent of units on the structure, depth, and thickness maps, available hydraulic-conductivity values on the thickness maps, and occurrences of intermediate-depth perched water on the piezometric-surface map. This is the last time that entire sets of the atlas will be prepared and distributed. However, as the 3-D geologic model, upon which the atlas is based, is updated each year the related sheets in the atlas will be updated as well. The latest version of any atlas sheet can be obtained from FIMAD. (See FIMAD project description.)

The atlas is valuable in that it documents our conceptual hydrogeologic model for the Pajarito Plateau. The information contained in the atlas is used to ensure that the most current, correct, and controlled values are distributed to LANL users for communicating, modeling, and decision-making.